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BEARING STRENGTHS OF BARE AND ALCLAD XA75S-T AND 24S-T81 ALUMINUM ALLOY SHEET

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INTRODUCTION

A report was recently issued covering an investigation of the bearing properties of the wrought aluminum alloys commonly used in aircraft construction (reference 1). Since this work was undertaken, two new materials, XA75S-T and 24S-T81, have been developed to the commercial stage for aircraft use. The object of this investigation was to determine the bearing yield and ultimate strengths of these new materials in the form of bare and alclad sheet.

PROCEDURE AND MATERIAL

The test procedure used in these determinations was the same as that previously described (reference 1). Figure 1 is a photograph of the test setup. Briefly, the tests involved loading single thicknesses of 0.064-inch sheet, 2 inches wide and cut parallel to the direction of rolling, in bearing on a 0.250-inch-diameter steel pin. The proportions of specimens used were the same as found to be satisfactory in previous tests. Measurements of the hole elongation were made with a filar micrometer microscope. Tests were made in triplicate for edge distances of 1.5, 2, and 4 times the pin diameter.

The material used for these tests was nominally 0.064-inch sheet. The 24S-T81 samples were commercial 24S-T sheet which had been artificially aged 12 hours at 375°F.

Tensile properties for the material are shown in table I. The values given may, with one exception, be classed as typical. The exception was the Alclad 24S-T81, for which the tensile strength was about 1 percent lower than the tentative minimum value. This difference was not considered sufficient, however, to affect the ratios of bearing to tensile properties determined.

RESULTS AND DISCUSSION

Individual bearing test results are shown in table II. The bearing yield strength values were obtained from the bearing stress-hole elongation curves shown in figures 2 to 5, using an offset from the initial straight-line portion of the curves equal to 2 percent of the pin diameter (0.005 in.). Indicated also in table II are the types of failure obtained. Failures by the tearing out of a portion of the sheet above the pin were predominate for edge distances of 1.5 and 2 pin diameters, and by upsetting or crushing the metal above the pin for edge distances of 4 diameters.

Ratios of average bearing to tensile properties are shown in table III. The ratios for both forms of 24S-T81 are in generally good agreement with those obtained for 24S-T and the other high strength aluminum alloys in previous tests (reference 1). Although the ratios for the XA75S-T are slightly higher in most cases than for the 24S-T81, it seems advisable and not unduly conservative to place XA75S-T in the same class as 24S-T81 and the other high strength alloys, as far as ratios of bearing to tensile properties are concerned. The following ratios are proposed as typical for these newer materials.

	Edge distance = 1.5D	Edge distance = 2.0D or greater
Bearing strength / Tensile strength	1.5	1.9
Bearing yield strength / Tensile yield strength	1.4	1.6

In the report previously referred to these ratios are identical to those suggested for the other high strength aluminum alloys. Although bearing yield and ultimate strengths do not show marked directional characteristics, it should be emphasized, as before, that the ratios given are based on tests parallel to the direction of rolling and should be applied only to tensile properties for this direction. This distinction is, of course, not necessary in the case of the 24S-T81 because this alloy does not exhibit directional characteristics in either bearing or tension.

CONCLUSIONS

The results of this investigation of the bearing properties of bare and alclad XA75S-T and 24S-T81 sheet seem to warrant the following conclusions:

1. The bearing strength data obtained in this investigation are representative of materials falling within the tentative specified limits for commercial production. Table I gives a summary of tensile properties and table II gives the results of the bearing tests.

2. Average ratios of bearing to tensile strengths and bearing yield to tensile yield strengths are given in table III for tests parallel to the direction of rolling. The ratios observed for the two forms of 24S-T81 are essentially the same as previously reported for 24S-T and the other high strength aluminum alloys. The ratios for the XA75S-T are slightly higher in most cases than for the 24S-T81, although, until more data are available, it is believed that the same ratios of bearing strengths to tensile strengths should be used.

3. The following ratios of bearing to tensile properties are proposed as typical for bare and alclad XA75S-T and 24S-T81 sheet. Although bearing yield and ultimate strengths do not show marked directional characteristics, it should be emphasized that when directional properties exist in tension, the ratios given apply only to the with-grain direction.

	Edge distance = 1.5D	2.0D or greater
$\frac{\text{Bearing strength}}{\text{Tensile strength}}$	1.5	1.9
$\frac{\text{Bearing yield strength}}{\text{Tensile yield strength}}$	1.4	1.6

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New Kensington, Pa., August 11, 1943.

REFERENCES

1. Moore, R. L., and Wescoat, C.: Bearing Strengths of Some Wrought-Aluminum Alloys. T.N. No. 901, NACA, Aug. 1943.

2. Anon: Tentative Methods of Tension Testing of Metallic Materials (E8-42), 1942 Book of A.S.T.M. Standards, Part I.

TABLE I.- TENSILE PROPERTIES OF XA75S-T AND 24S-T81

SHEET USED FOR BEARING TESTS

[Nominal thickness, 0.064 in.]

Alloy and temper	Sample number	Ultimate strength (lb/sq in.)	Yield strength (offset = 0.2 percent) (lb/sq in.)	Elongation in 2 in. (percent)
XA75S-T	52618	72,500	63,800	14.0
Alclad XA75S-T[1]	52611	72,200	62,100	13.0
24S-T81	59381	72,200	65,100	6.5
Alclad 24S-T81[1]	39225	63,500	57,900	7.0

Note: The above values are results of single tests in with-grain direction. Type of specimen shown in fig. 2 of reference 2.

[1]5 percent alclad coating on each side.

TABLE III.- AVERAGE RATIOS OF BEARING TO TENSILE STRENGTH

FOR XA75S-T AND 24S-T81 SHEET

Alloy and temper	Edge distance = 1.5 x pin diam.			Edge distance = 2 x pin diam.			Edge distance = 4 x pin diam.		
	$\frac{BS}{TS}$	$\frac{BYS}{TS}$	$\frac{BYS}{TYS}$	$\frac{BS}{TS}$	$\frac{BYS}{TS}$	$\frac{BYS}{TYS}$	$\frac{BS}{TS}$	$\frac{BYS}{TS}$	$\frac{BYS}{TYS}$
XA75S-T	1.72	1.32	1.51	2.23	1.50	1.71	2.61	1.5[illegible]	1.79
Alclad XA75S-T	1.62	1.22	1.42	2.08	1.38	1.61	2.35	1.47	1.71
24S-T81	1.45	1.28	1.42	1.97	1.43	1.59	2.39	1.46	1.62
Alclad 24S-T81	1.54	1.33	1.46	2.06	1.46	1.61	2.48	1.51	1.65

Note: All bearing tests on 1/4-in. diam. steel pin (D/t = 4). Specimens 2 in. wide loaded parallel to direction of grain.

BS - bearing strength
BYS - bearing yield strength (offset = 0.02 x pin diam. = 0.005 in.)
TS - tensile strength (with grain)
TYS - tensile yield strength (offset = 0.02 percent) (with grain)

TABLE II.- BEARING STRENGTHS OF XA75S-T AND 24S-T81 SHEET

[Nominal thickness, 0.064 in.]

Alloy and temper	Test number	Bearing strengths (lb/sq in.)								
		Edge distance = 1.5 x pin diam.		Type of failure[2]	Edge distance = 2 x pin diam.		Type of failure[2]	Edge distance = 4 x pin diam.		Type of failure[2]
		Ultimate	Yield[1]		Ultimate	Yield[1]		Ultimate	Yield[1]	
XA75S-T	1	125,600	97,000	S	162,500	109,000	S	178,800	170,000	B
	2	123,800	96,000	S	159,400	108,000	S	206,300	114,500	B
	3	125,000	96,000	S	163,100	110,000	S	182,500	118,000	B
	Av.	124,800	96,300		161,700	109,000		189,200	114,200	
Alclad XA75S-T[3]	1	117,500	89,000	S	148,500	98,000	S	180,400	105,500	B
	2	116,600	87,000	S	151,500	100,000	S	165,400	106,500	B
	3	116,600	88,000	S	150,300	101,000	S	164,100	106,500	B
	Av.	116,900	88,000		150,100	99,700		170,000	106,200	
24S-T81	1	106,000	94,000	S	143,300	104,000	S	186,900	107,000	B
	2	104,600	93,000	S	144,500	102,000	S	179,000	106,500	B
	3	102,400	91,000	S	139,400	104,000	S	152,100	103,500	B
	Av.	104,300	92,700		142,400	103,500		172,700	105,700	
Alclad 24S-T81[3]	1	97,500	84,000	S	132,300	95,000	S	146,800	97,500	B
	2	96,800	84,000	S	132,300	93,000	B	162,700	96,000	B
	3	98,700	85,000	S	127,800	91,000	B	162,000	94,000	B
	Av.	97,700	84,500		130,800	93,000		157,200	95,800	

Note: All tests on 1/4 in. diam. steel pin (D/t = 4). Specimens 2 in. wide loaded parallel to direction of grain.

[1]Stress corresponding to offset of 2 percent of hole diameter from initial straight-line portion of bearing stress-hole elongation curves shown in figs. 2 to 5 (0.005 in. offset for 1/4-in. diam. pin).

[2]Type of failure: B - Bearing, S - shear.

[3]5 percent alclad coating on each side.

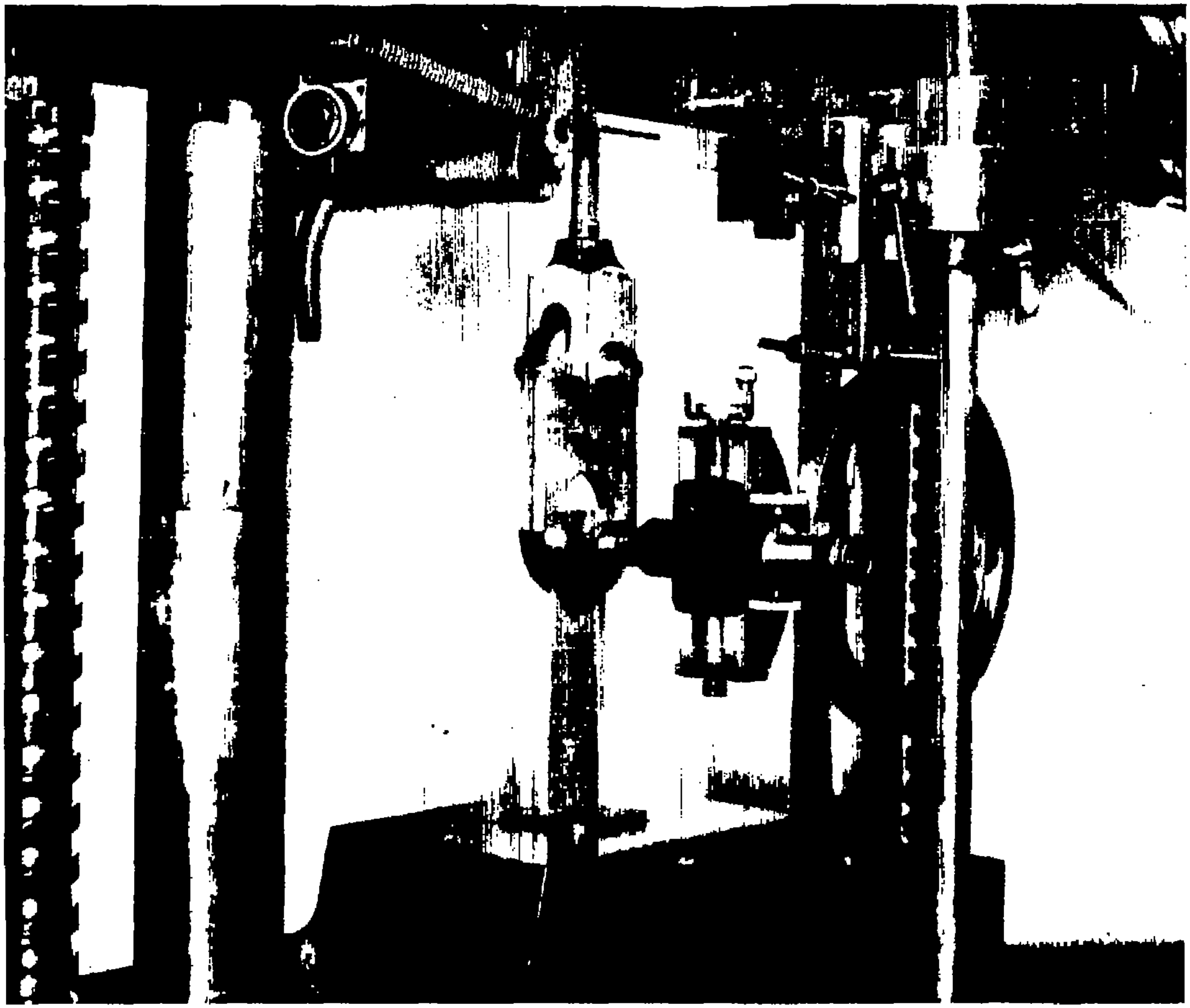
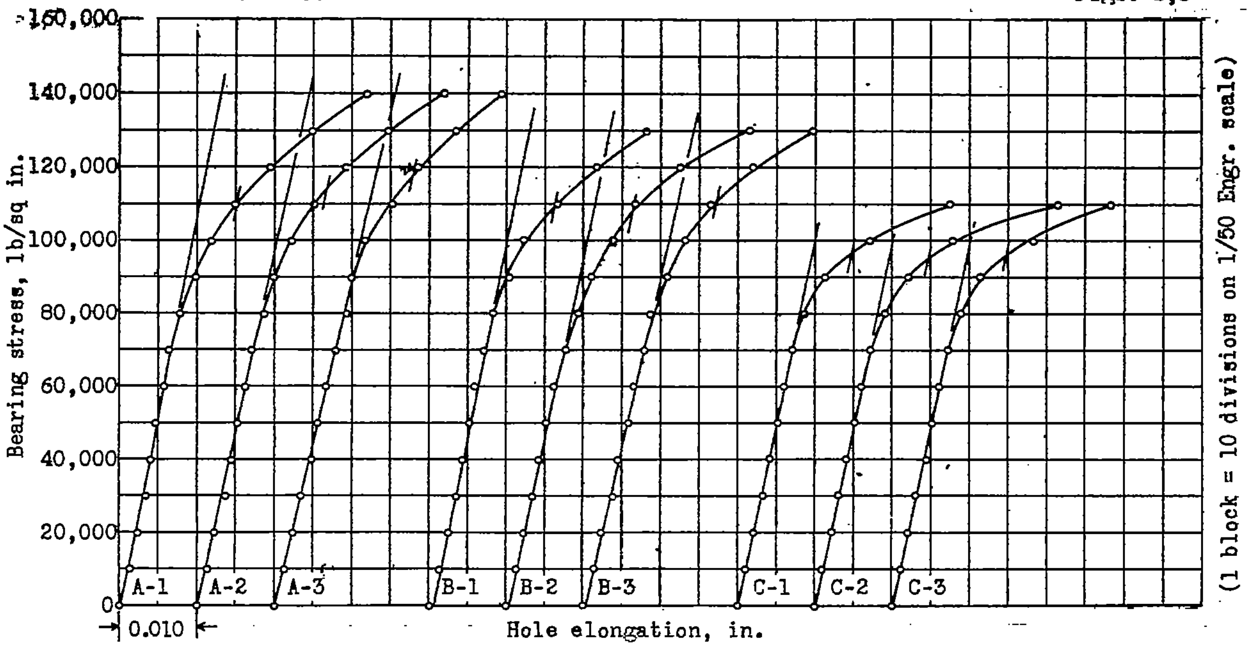


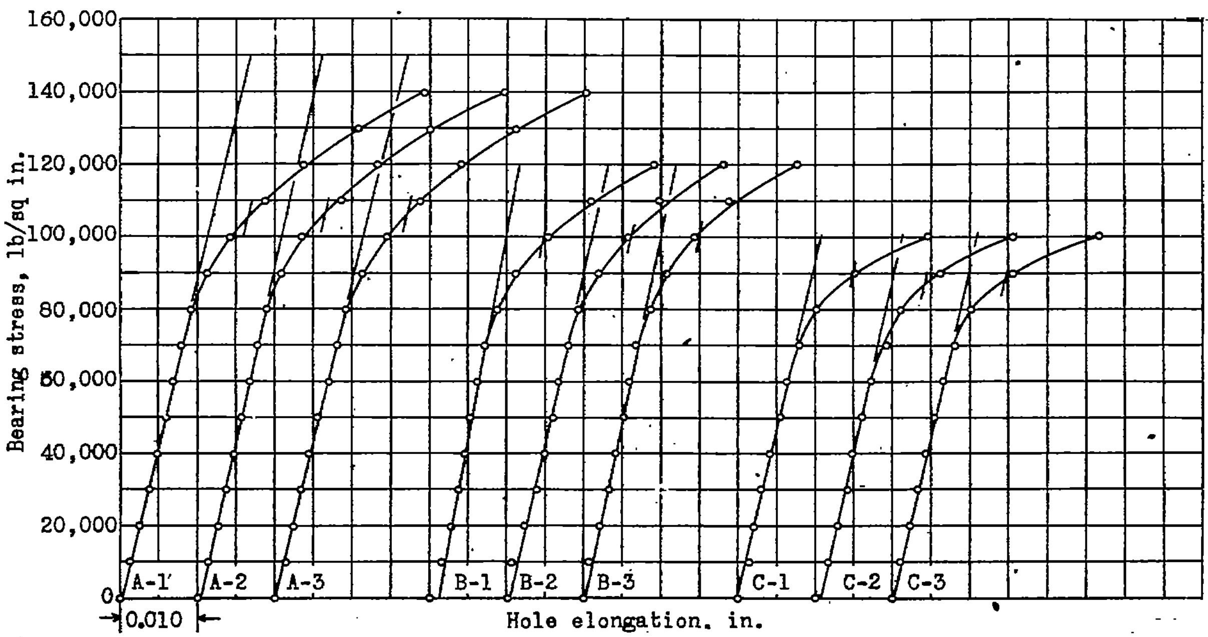
Figure 1.- Arrangement for bearing tests using Filar micrometer microscope for measurements of hole elongation.



Pin daimeter = 1/4 in.
Sheet thickness = 0.064 in.
Specimen width = 2 in.

A-1, A-2 and A-3: edge distance = 4× pin diameter
B-1, B-2 and B-3: edge distance = 2× pin diameter
C-1, C-2 and C-3: edge distance = 1.5× pin diameter

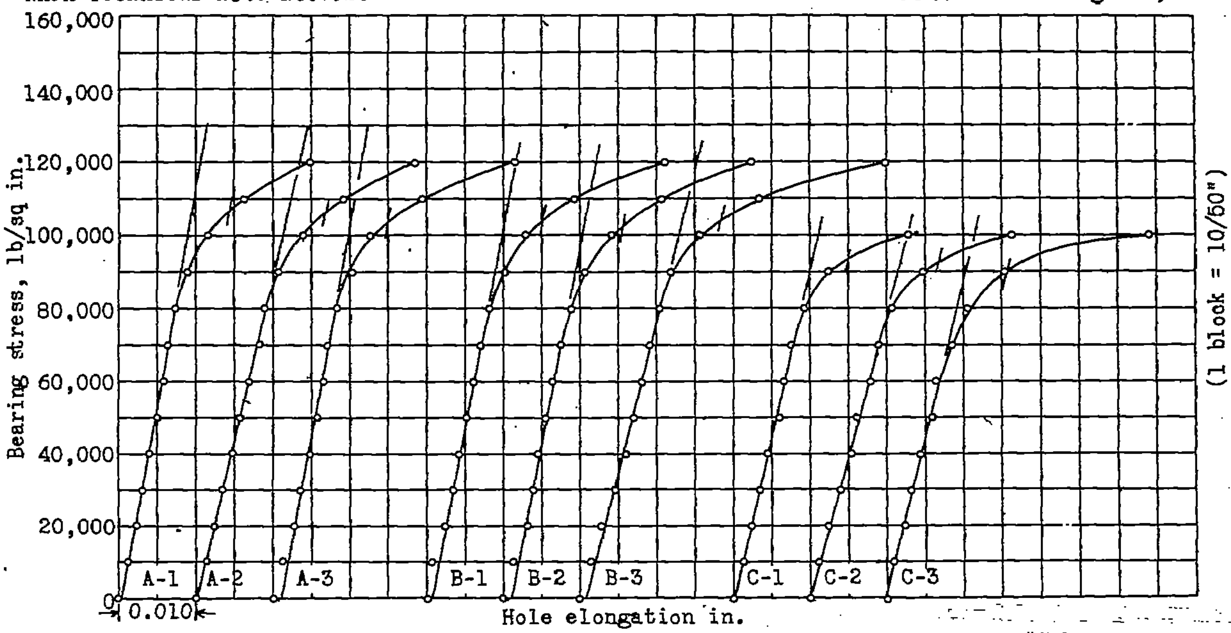
Figure 2.- Bearing stress-hole elongation curves for aluminum alloy sheet, bare XA75S-T. Test 12-29.



Pin diameter = 1/4 in.
Sheet thickness = 0.064 in.
Specimen width = 2 in.

A-1, A-2, A-3: edge distance = 4× pin diameter
B-1, B-2, B-3: edge distance = 2x pin diameter
C-1, C-2, C-3: edge distance = 1.5× pin diameter

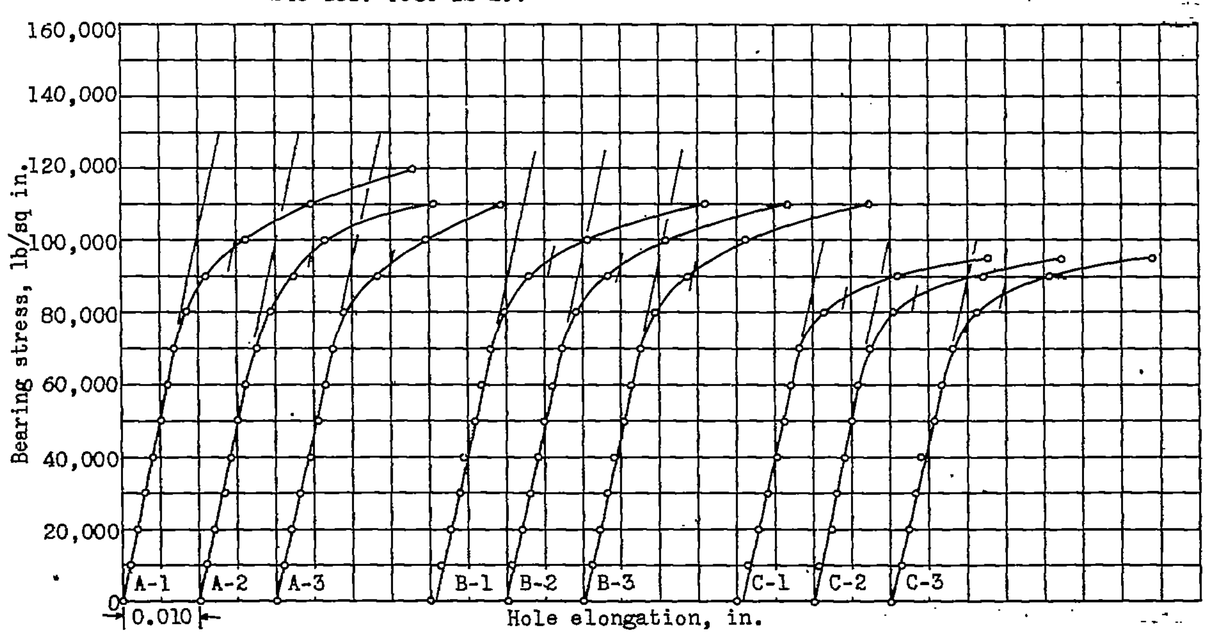
Figure 3.- Bearing stress-hole elongation curves for aluminum alloy sheet, Alclad XA75S-T. Test 12-29.



Pin diameter = 1/4 in.
Sheet thickness = 0.064 in.
Specimen width = 2 in.

A-1,A-2 and A-3: edge distance = 4× pin diameter
B-1,B-2 and B-3: edge distance = 2× pin diameter
C-1,C-2 and C-3: edge distance = 1.5× pin diameter

Figure 4.- Bearing stress-hole elongation curves for aluminum alloy sheet, bare 24S-T81. Test 12-29.



Pin diameter = 1/4 in.
Sheet thickness = 0.064 in.
Specimen width = 2 in.

A-1,A-2 and A-3: edge distance = 4× pin diameter
B-1,B-2 and B-3: edge distance = 2× pin diameter
C-1,C-2,and C-3; edge distance = 1.5× pin diamter

Figure 5.- Bearing stress-hole elongation curves for aluminum alloy sheet, Alclad 24S-T81. Test 12-29.